

An Adolescent Female Neandertal Mandible From Montgaudier Cave, Charente, France

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ABSTRACT In 1974, an incomplete human mandible was discovered in the site of Montgaudier Cave, along the Tardoire (Charente), France. The mandible was found in association with stone tools and animal bones in geological deposits referable to the very end of the Middle Pleistocene or the beginning of the Upper Pleistocene.

The mandible preserves much of the anterior part of the body and three permanent teeth: left lateral incisor, canine and first molar. Estimates based on tooth eruption of modern humans, as well as occlusal wear and root development, suggest an age at death of between 12.5 and 14.5 years. Morphologically, the fossil possesses features, such as a lack of a chin and multiple mental foramina, which have been observed on immature Neandertal mandibular specimens from Europe. Comparison with these immature European Neandertals indicates that the jaw and teeth of the Montgaudier mandible are small for its chronological age, suggesting it was that of a female. *Am J Phys Anthropol* 103:507-527, 1997 © 1997 Wiley-Liss, Inc.

The examination and reconstruction of the patterns of growth and development that characterized earlier hominines has long been a focus of interest in paleoanthropology (reviewed in Conroy and Kuykendall, 1995; Dean, 1989; Dean et al., 1986; Macho and Wood, 1995; Mann et al., 1990a; Smith, 1992; Tillier, 1995; Tillier et al., 1995). These studies have emphasized the important role development played in the evolutionary processes that led to the appearance of modern humans. While many of these discussions have dealt with the early hominines of the genus *Australopithecus*, and have focussed on the origins of the modern human pattern of prolonged childhood (i.e., Bromage and Dean, 1985; Conroy and Kuykendall, 1995; Mann et al., 1991b), later-in-time members of the hominine lineage have also been investigated (e.g. Minugh-Purvis, 1988; Dean

et al., 1986; Ramirez-Rozzi, 1993, 1996). Tillier (1979, 1981, 1982, 1983, 1984, 1987, 1988, 1989, 1991) has described the anatomy of many European and Middle Eastern immature Neandertals and early modern humans, using these descriptions as a basis for understanding their growth and development. Minugh-Purvis (1988) utilized a cross-sectional technique to describe the developmental patterns of the cranial and facial skeleton of Upper Pleistocene hominines. Dean et al. (1986), Ramirez-Rozzi (1993, 1996), and Mann et al. (1990b) have examined the histology of Neandertal teeth to calculate the rate and timing of dental matu-

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ration. Despite these studies, there remain many questions about the precise level of similarity in the patterns of growth and development between modern humans and Neandertals. Certainly, greater understanding of the nature of Neandertal maturational patterns can provide additional insight into their phylogenetic relationships as well as the level of their behavioral complexity.

One of the major limitations in these studies is the small number of suitable immature fossil specimens available for study. Although Tillier (1995) has estimated that about 25% of the entire Neandertal fossil sample are the remains of immature individuals—a minimum of 60–70 individuals—their use in studies of maturational patterns remains difficult. For one thing, because of the state of bony ossification at death, many of these specimens are very fragmentary and incomplete. In order to cross-sectionally compile a chain of age-graded Neandertal fossils from early immaturity to adulthood, specimens from sites all over the European continent must be employed. This complicates the study of purely age-related features by introducing other variables such as populational differences between the eastern and western European sample, as well as the temporal differences that may have characterized earlier and later members of archaic *Homo sapiens*. Also possibly confounding the examination of age-related features in these immature specimens are the variations associated with sexual dimorphism. A feature, for example, that might be described as more mature for a given age, as compared with the comparable state in modern humans, may be more a reflection of sex than representative of a significant difference from modern humans. Thus, the larger the sample of immature fossil specimens of known sex available for study, the greater the ability to assess individual variation and isolate age-related characters, and thus to contribute to the accurate picture of Neandertal growth and development.

The specimen examined here, a partial mandible from an immature individual from the site of Montgaudier in the Charente, France, was briefly described in 1976 (Du-

port and Vandermeersch, 1976). It has been used in analyses of immature Neandertals (e.g., Minugh-Purvis, 1988; Hublin and Tillier, 1981; Tillier, 1984), but it has never been comprehensively described, nor its age at death and sex fully analyzed.

DISCOVERY AND GEOLOGICAL CONTEXT

Montgaudier is a large, collapsed cave with a complicated stratigraphy, located near the town of Montbron on the left bank of the river Tardoire (a tributary of the Charente), some 25 km east of Angoulême, Charente (45°41'N, 0°28'E). Montgaudier is one of several paleolithic sites in the valley of the Tardoire, which include La Chaise-de-Vouthon, le Placard, Vilhonneur and Marillac.

Montgaudier Cave has been excavated many times since its discovery in the middle of the last century, and was most recently investigated by Duport in a series of excavations beginning in 1966 (Bourgeois and Delaunay, 1865; Duport, 1967, 1971, 1972, 1974, 1976, 1987; Bouvier and Duport, 1969; Bouvier et al., 1987; Debénath, 1974; Debénath and Duport, 1969, 1971, 1972; Marquet, 1987, 1989; Boukhir, 1992).

The site is composed of a number of shelters and grottos all more or less connected, with a total area of about 2,000 m² (Boukhir, 1992). Because of the complexity of the cave's geology and the numerous, often undocumented and unpublished excavations over the past century and a half, it is now difficult to reconstruct the depositional history and the relationships of the numerous layers found in different parts of the cave.

The partial mandible was discovered by L. Duport in 1974 in deposits under the *Grand Porch*, a large overhang in front of the main cave deposits. According to Duport (1974), an enormous block of breccia was encountered during excavations in square E'6. This block, which is a part of an extensive series of blocks at this level in the deposits, contained Mousterian implements and had been displaced downward from its original position in a connecting, but higher cavern. The block appears to represent a time period considerably later than the apparently undisturbed deposits underlying it. Below the

block, a series of eight layers was excavated, in one of which, Layer 3, Duport discovered a partial human mandible.

In the same layer, directly associated with the incomplete human mandible, were the bones of bovids, reindeer, bear and horses (not further identified). Also found in this layer were stone tools which Duport (1974) termed "pre-mousterian," but which have not been given a more precise typological definition.

In the article announcing the discovery of the mandible, Duport, reasoning from the position of the fossil in the deposit and the presence of tools he considered older than the Mousterian tools found in the breccia block above the mandible layer, suggested that the mandible dated to the beginning of the Würm. Other investigators (i.e., Boukhir, 1992; Marquet, 1989) have also concluded that the layers of the *Grand Porch* beneath the breccia block are undisturbed and are, moreover, the oldest in the cave, perhaps dating to the beginning of the Würm, or even earlier.

Recent stratigraphic and sedimentological research by Boukhir (1992) at Montgaudier has been directed at a fuller understanding of the stratigraphic context of the various layers in the different parts of the cave and the development of a reasonable chronological framework. This work confirms the results of earlier geological investigations (Debénath, 1974) in recognizing the layers of the *Grand Porch* as the oldest in the cave. Although Boukhir attributes these deposits to the early Würm or the Riss/Würm Interglacial, he did not directly investigate the deposits in which the mandible was found.

Marquet (1987, 1989) examined lemming bones from a number of sites in western France in constructing a paleoenvironmental and chronological framework. At Montgaudier, he identified two species of lemmings (*Lagurus lagurus* and *Dicrostonyx torquatus*) and by correlation with other sites suggested that the layers below the breccia block, including the one in which the Montgaudier mandible was discovered, are of Riss III age.

The available evidence suggests that the layer in which the mandible was found can

be broadly attributed to the span ranging from the latest Middle Pleistocene to the early Late Pleistocene. The mandible may therefore be appreciatively earlier than most other western European Neandertals, perhaps equivalent in age to the hominine fossils from Montmaurin and Krapina, the latter now dated about 130,000 years (Rink et al., 1995), though later-in-time than the Ehringsdorf remains [now dated at between 146,000 and 205,000 years (Schwarcz, 1980)]. However, the geology of the cave is exceedingly complex, and many details regarding the patterns of deposition and especially relationships of the deposits in the different parts of the cave have not been worked out. Thus, the geological context and temporal position of the mandible remains uncertain, and attribution of this specimen to a later middle or early Upper Pleistocene age should be considered tentative at the present time.

In addition to the partial mandible, the Upper Paleolithic layers of Montgaudier Cave have also yielded a number of hominine fossils, including cranial and postcranial remains, all associated with a Magdalenian industry (Oakley et al., 1971; Debénath, 1974; Bourgeois and Delaunay, 1865; Debénath and Duport, 1972; Duport, 1971; Gambier, 1987).

COMPARATIVE SAMPLE

Minugh-Purvis (1988) has provided a list of immature archaic *Homo sapiens* fossils from western and eastern Europe which possess complete mandibles or partial mandibles that can be used in comparative studies with the Montgaudier jaw, while Hublin and Tillier (1981, 1988) and Tillier (1984) provide details on the immature specimen from Jebel Irhoud in Morocco, Irhoud 3, and the early modern human, Qafzeh 11 from Qafzeh cave in northern Israel. Table 1 lists these specimens with estimates of the ages at death of the European specimens listed by Minugh-Purvis (1988), and Wolpoff (1979, 1996, personal communication). Tillier (1984) has estimated the age at death of the Qafzeh 11 youth as about 12–13 years, while the Irhoud 3 youngster is estimated to have died at approximately 8–9 years of age (Hublin and Tillier, 1981, 1988). The estimated age at death (see below) of the Montgaudier

TABLE 1. Immature fossil *Homo sapiens* specimens with preserved mandibles or partial mandibles, of comparable age with Montgaudier; estimated age of 12.5–14.5 years

| Specimen | Age estimates (years) | |
|------------------------------|----------------------------|----------------------|
| | Minugh-Purvis ¹ | Wolpoff ² |
| Western Europe | | |
| Hortus 2 & 3 | 9 | 9 |
| Malarnaud | 15 | 14 |
| Le Moustier 1 | 16.5 | 13 |
| Petit-Puymoyen 1 | 16–17 | 13 |
| Eastern Europe | | |
| Krapina B | 9.5 | — |
| Zaskalnaya VI | 9–10 | 10 |
| Krapina C | 11 | — |
| Sipka 1 | 10–10.5 | 9 |
| Teshik-Tash 1 | 11 | 8.5 |
| Ehringsdorf 7 | 12 | 10.5 |
| Krapina E | 15–17 | — |
| Middle East and North Africa | | |
| Qafzeh 11 ³ | | 12–13 |
| Jebel Irhoud 3 ⁴ | | 8–9 |

¹ Minugh-Purvis (1988).

² Wolpoff (1996; personal communication).

³ Tillier (1984).

⁴ Hublin and Tillier (1981).

individual is between 12.5 and 14.5 years. Except for the Qafzeh and Jebel Irhoud specimens, the remainder of the specimens listed in Table 1 are generally considered to be immature Neandertals (Wolpoff, 1996; Stringer and Gamble, 1993).

The samples of living humans used in the comparisons are from Minugh-Purvis (1988). In her analysis of Upper Pleistocene *Homo sapiens* cranio-facial growth, Minugh-Purvis (1988) collected data on two samples of immature modern humans: 123 from the Libben archaeological site in Ohio, and 40 from the third millennium BC village site of Tepe Hissar in Iran, a total of 163 individuals. Based on the patterns of cranial and dental development observed in modern human children, Minugh-Purvis (1988) evaluated the attainment of various developmental events in the braincase, facial skeleton and dentition of these archaeological specimens, dividing the total sample into seven age-delimited groups between birth and adulthood. The three groupings most appropriate for comparison with the Montgaudier specimen are those termed by Minugh-Purvis (1988): "late childhood" (occurring in modern females on average between 8 and 10 years and in males between 8 and 12 years); "early adolescence" (occurring be-

tween 10/10.5 and 12 years in females and 11 and 12 years in males); and "adolescence to maturity" (occurring in females and males between 12 and 18+ years).

Metric parameters of the three teeth preserved in the Montgaudier mandible are compared to a series of modern humans compiled by Wolpoff (1971), as well as to a sample from the European Mesolithic and Upper Paleolithic (Flecher, 1975), and other Neandertals (Wolpoff, 1971; Smith, 1976; Patte, 1960).

MANDIBULAR MORPHOLOGY

The mandible is represented by the anterior corpus and parts of the right and left rami from the left M₂ root to the position of the right P₃ (Figs. 1–5). In general, the bone is very well preserved and its relief can be studied in detail. The bone is dense, with no indications of pathology. The symphyseal region is complete except for some missing bone on the alveolar margin, labially and lingually surrounding the alveoli of the central incisors. On the right side, the bone is broken obliquely from the inferior border approximately below the middle of the P₃ to the mesial edge of the alveolus of the canine. On the left side, the breakage is vertical and approximately at the level of the M₂, exposing the mesial alveoli of the M₂ and the outline of the mandibular foramen.

On the left side, the I₂, canine and M₁ are preserved. The alveoli for the I₁, P₃ and P₄, and the mesial root of the M₂, as well as the distal contact facet on the M₁, indicate that the successional teeth, I₁–P₄, as well as the M₂, had erupted, at least on the left side. There are no right side teeth preserved, but there are complete alveoli for the right I₁ and I₂ and the mesial margin of the canine alveolus.

The overall size of the bone, as well as the relative lack of wear on the preserved teeth, especially on the lingual cusps of the first molar, and the two anterior teeth, identify this specimen as immature.

Symphyseal region

When the fossil rests on its base, the external profile of the symphyseal region is vertical or leans slightly backward. There is no mandibular curve (*incurvatio mandibu-*

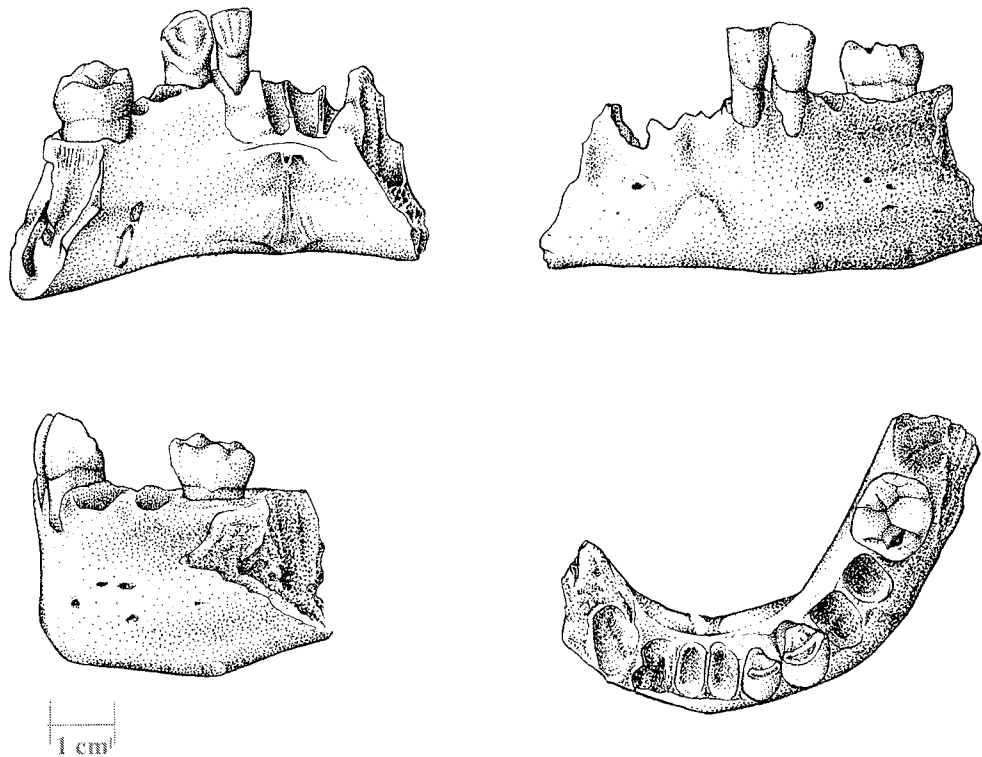


Fig. 1. Four views of the Montgaudier mandible. Approximately full size (from Duport and Vandermeersch, 1976).

lae) (Weidenreich, 1936) and therefore no *mentum osseum*; rather a small swelling is situated on the inferior third of the external face, represented by the *tuber syphyseos*. It is not accompanied laterally by the *tubercula lateralia*. There is therefore a hint of a *trigonum mentale* but this is not the classic morphology encountered in most modern humans. The condition in the Montgaudier specimen is similar to the anatomy observed in the mandible from the immature individual from Malarnaud, but in this latter fossil, the *tuber syphyseos* is barely evident and it may be described as more obvious to the touch than to sight. This morphology is markedly different from that of the Qafzeh 11 individual from Israel (Tillier, 1984), which possesses a modern human-like *trigonum mentale*. Of approximately the same age-at-death as the individual from Montgaudier, the Qafzeh 11 child differs in many of its cranial and mandibular morphological features from immature European Neander-

tals, and resembles the adult sample from this site, a grouping often considered early modern human in its morphology (Vandermeersch, 1981; Tillier, 1984). In their analysis of the morphology of the Jebel Irhoud 3 mandible from Morocco, Hublin and Tillier (1981, 1988) conclude that this specimen, aged to about 8–9 years, possessed a mandibular symphysis somewhat less modern human-like than that observed in the Qafzeh 11 individual. There is no *trigonum mentale*. Nevertheless, these authors suggest that the overall morphology of the anterior portion of the mandibular symphysis in the Irhoud 3 child is more like that in modern human children than it is to the sample of immature European Neandertals.

On the Montgaudier mandible, the superior part of the internal face of the symphysis is missing, but the area at the level of the lateral incisor, the canine, and the base of the alveolus of the I_1 is present. This region does not display an obliquity, thus suggest-



Fig. 2. Montgaudier mandible, Norma lateralis. Full size.



Fig. 3. Montgaudier mandible, occlusal. Full size.

ing that it did not possess a *planum alveolare*. This is similar to the pattern observed in the Krapina E mandible, but quite different than the situation in the Ehringsdorf child, where the *planum alveolare* is quite distinct as an oblique surface reaching almost to the middle of the internal face (Fig. 6). A similar condition exists in the younger-in-age Irhoud 3 mandible, where a *planum alveolare* is present (Hublin and Tillier, 1981, 1988). The Qafzeh 11 child, in contrast, possesses a vertical profile (Tillier, 1984), like that in modern humans and in the Montgaudier specimen.

On the Montgaudier fossil, the genioglossal fossa opens at mid-level of the mandible. It is transversely elongated and divided in two by a sagittal crest [*spina mentalis* of Weidenreich (1936)] on the top of which an open, small genial canal is present. This crest, or mental spine, continues below the genioglossous and joins the interdigastric spine. The interdigastric spine is not a single

entity, but a series of very fine accessory crests which separate at the border of the genial canal and rejoin in the interdigastric region in a fan-shaped form. A comparable arrangement can be found on the adult Ehringsdorf mandible and on the Malarnaud specimen. However, on the Malarnaud fossil, the genial crests are indented on the transverse inferior torus; on the Montgaudier mandible, they pass above this torus. On the Montgaudier specimen, this torus is progressively attenuated laterally and disappears on a line between P_3 and P_4 . In contrast to the condition observed in the Malarnaud mandible, where the genioglossal fossa is poorly developed and is little more than a rugosity of bone, it is strongly developed on the Montgaudier mandible.

The mylohyoid line is well marked on the internal face of the Montgaudier specimen to a point below the mesial edge of the P_4 . Because of the development of the transverse inferior torus, there is no sublingual fossa.

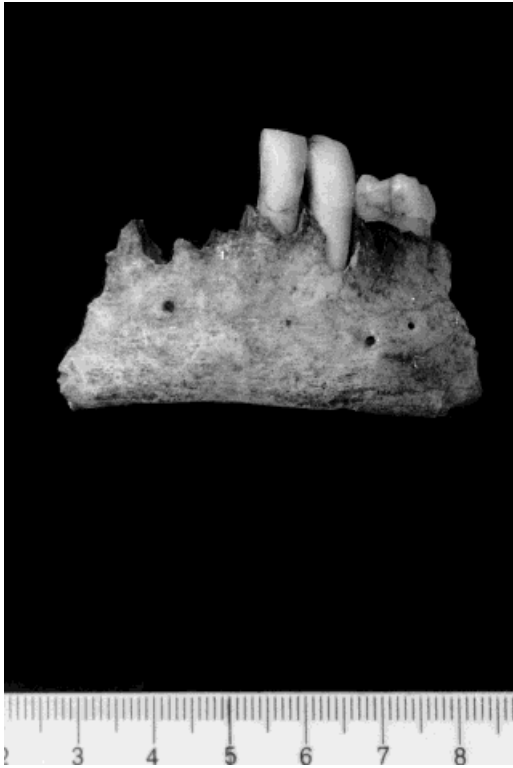


Fig. 4. Montgaudier mandible, Norma frontalis. Full size.

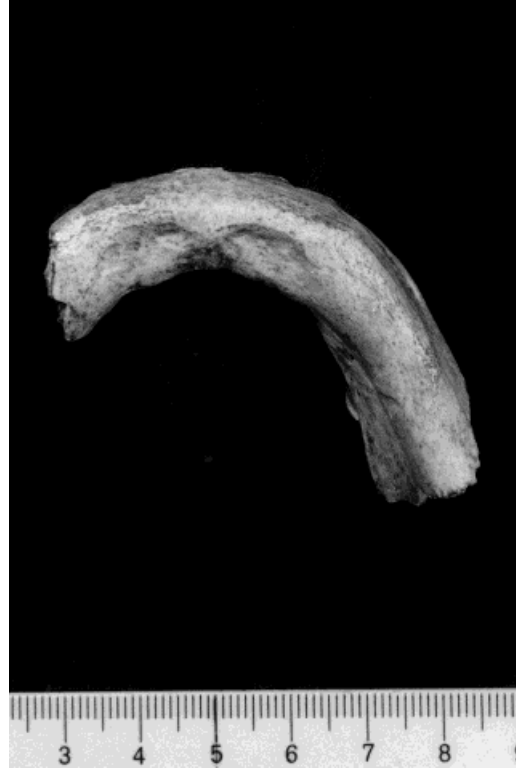


Fig. 5. Montgaudier mandible, Norma basalis. Full size.

On the inferior face of the symphyseal region, the imprint of the digastric muscles is strongly marked. In contrast, the impressions of these muscles are poorly marked on the Ehringsdorf 7 child. While the digastric grooves are somewhat more apparent on the Krapina E specimen, they are not nearly as well defined as on the Montgaudier fossil. Both of these mandibles, though representing individuals of approximately the same dental age at death as the Montgaudier specimen, are considerably larger in size. In the Montgaudier fossil, the digastric grooves are oriented inferiorly, are oval in shape and are clearly separated from each other by a strongly marked digastric spine; they are relatively short and narrow. On the Malarnaud specimen, these imprints are elongated and their limits are not well marked. The grooves are more inferiorly oriented, and they occupy the entire inferior face of the symphyseal region.

Table 2 provides symphyseal height and thickness measurements for the Montgaudier fossil compared with a sample of immature European Neandertals with younger and older estimated ages at death, and with Qafzeh 11 and Jebel Irhoud 3. Table 2 also lists comparable measurements from a series of modern humans divided into three age delimited categories.

In symphyseal height and thickness, the Montgaudier mandible is the smallest Neandertal specimen listed, including Hortus 2 & 3, whose estimated age at death of about 9 years, is considerably younger than the 12.5–14.5 years estimated age at death for the Montgaudier specimen. Larger immature Neandertals of more or less comparable age to the Montgaudier specimen include the Ehringsdorf child, variously aged to between 10.5 and 12 years, Krapina E, aged at about 14–15 years, and Petit-Puymoyen and Le Moustier, both aged to between 13 and

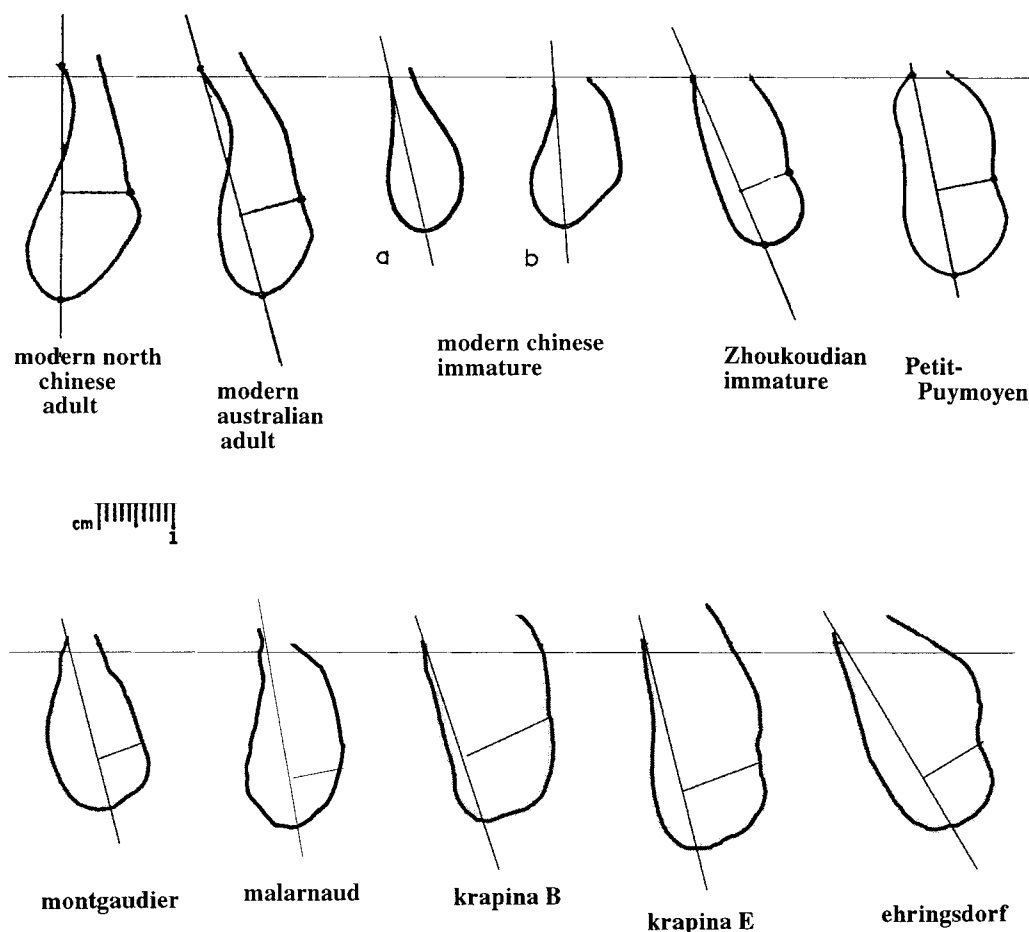


Fig. 6. Median sagittal cross-sections of the symphyses of the Montgaudier mandible and adult and immature samples of *Homo erectus* and living and extinct *Homo sapiens* (modern humans and Zhoukoudian *Homo erectus* after Weidenreich, 1936; Petit-Puymoyen after Gabis, 1956).

16.5 years. Thus, with the exception of the Malarnaud mandible, aged at about 14–15 years, and considered an immature female (Wolpoff, 1996), the symphyseal dimensions of the Montgaudier specimen are considerably smaller than all of its close-in-age peers. It is also smaller than the younger-in-age Jebel Irhoud 3 specimen and the comparably aged Qafzeh 11, the latter usually identified as an early modern human. Indeed, it is at the low end of the range of modern human children aged between 8 and 12 years (late childhood and adolescent samples) and below the range of modern human children aged 12–18+ years (late adolescent to maturity).

Figure 6 illustrates median sagittal cross-sections through the symphyseal region of a sample of immature Neandertal mandibles from Europe, the immature BI mandible from Zhoukoudian (Weidenreich, 1936), as well as adult and immature living humans. The small size of the Montgaudier specimen is obvious, as is its general morphological similarity to other immature Neandertals, such as those from Petit-Puymoyen, Malarnaud, and Krapina mandibles B and E.

Horizontal rami

In common with many Neandertal rami, the Montgaudier left horizontal ramus possesses multiple mental foramina. There are

TABLE 2. Symphyseal height, thickness and index of robusticity (thickness/height \times 100)

| Specimen ¹ | Age at death (years) | Height (mm) | Thickness (mm) | Index of robusticity |
|-----------------------------|----------------------|-------------|----------------|----------------------|
| Hortus | 9 | 23.6 | 13.8 | 58.5 |
| Teshik Tash 1 | 8.5–11 | 27.0 | 13.7 | 50.7 |
| Jebel Irhoud 3 ² | 8–9 | 26.7 | 13.7 | 51.3 |
| Modern human sample | 8–12 | 22.0–27.2 | 11.7–14.7 | 53.2–54.0 |
| Krapina B | 9.5 | (26.0) | (12.0) | (46.2) |
| Krapina C | 11 | 23.7 | 13.6 | 57.4 |
| Sipka 1 | 9–10.5 | 28.4 | 14.0 | 49.3 |
| Ehringsdorf 7 | 10.5–12 | 28.3 | 15.3 | 54.1 |
| Modern human sample | 10–12 | 21.3–30.4 | 12.0–16.9 | 55.1–56.3 |
| Montgaudier | 12.5–14.5 | 22.0 | 11.8 | 53.6 |
| Qafzeh 11 ³ | 12–13 | 30 | 14 | 46.6 |
| Krapina E | 15–17 | 31.4 | 14.1 | 44.9 |
| Malarnaud 1 | 14–15 | 25.3 | 12.8 | 50.6 |
| Le Moustier 1 ⁴ | 13–16.5 | 30.0 | 15.0 | 50.0 |
| Petit-Puymoyen 1 | 16–17 | 28.1 | 12.2 | 43.4 |
| Modern human sample | 12–18+ | 24.5–35.0 | 10.8–15.3 | 43.7–44.1 |

¹ All measurements except Irhoud, Qafzeh and Montgaudier are from Minugh-Purvis (1988).

² Hublin and Tillier (1981).

³ Tillier (1984).

⁴ Measurements of Le Moustier are taken from a cast (Minugh-Purvis, 1988).

four orifices in addition to a very small accessory canal. The most anterior of the mental foramina, with its opening facing anterior-inferiorly, is located immediately below the mesial part of the P₃ and on the inferior third of the bone. The second foramen, open perpendicularly to the surface of the bone, is in the middle of the corpus and between P₃ and P₄. The third foramen is the most superior of the four. Its opening faces postero-superiorly. It is on the same level with the second, but located posteriorly, and directly below the middle of the P₄. The last foramen, with its opening facing inferiorly, is also located under the P₄, and 2.5 mm below the third foramen. Finally, there is a small accessory orifice at the level of the second foramina, but situated farther back, located below the middle of the M₁. The center of the highest mental foramen is located 13.1 mm from the superior surface of the corpus, whereas the lowest of the major foramina, which is also the most posterior, is located 8 mm from the inferior surface.

On the right horizontal ramus, a foramen is present on the broken base of the alveolus of the I₂, 12 mm from the inferior surface of the corpus. This foramen marks the extremity of a canal oriented towards the basal and anterior surfaces. It may be a mental foramen; if it is, its anterior position under the lateral incisor would be remarkable.

In contrast, both the Qafzeh 11 and Jebel Irhoud 3 immature individuals possess single, large, mental foramina (Tillier, 1984; Hublin and Tillier, 1981).

External relief is strongly developed on the corpus of the Montgaudier mandibular fragment, more so than, for example, on the corresponding structures on the Malarnaud mandible. The superior lateral torus is very strong, following a course anteriorly until its termination at the most anterior margin of the mental foramina, inferior to the mesial surface of the P₃. Below the torus, there is a slight depression. The marginal rim (*torus marginalis*) terminates below the P₃ with an anterior marginal tubercle. On the inferior surface, there is a small bony prominence with a rugose surface located externally at the level of the M₁.

Tables 3 and 4 list corpus measurements of the Montgaudier mandible, comparable measurements from other immature European Neandertals, and samples of modern humans. Table 5 provides data on corpus robusticity at P₃ for a more limited sample. Measurements of corpus thickness (Table 3), like those of the symphysis, indicate that the Montgaudier jaw is very small in comparison to other close-in-age Neandertal specimens, even including Krapina C (around 11 years of age) and Teshik-Tash (estimated to be 8.5 or 11 years of age), whose stages of dental development suggest they are young-

TABLE 3. *Corpus thickness (mm) at canine, P₃, P₄ and M₁*

| Specimen ¹ | Age at death (years) | Canine | P ₃ /dpm ₁ | P ₄ /dpm ₂ | M ₁ |
|----------------------------|----------------------|-----------|----------------------------------|----------------------------------|----------------|
| Hortus 2 & 3 | 9 | 14.2 | — | — | — |
| Teshik-Tash 1 | 8.5–11 | 17.0 | 16.6 | 15.1 | 15.8 |
| Modern human sample | 8–12 | 11.1–14.7 | 10.8–14.5 | 11.5–18.8 | 12.3–15.4 |
| Krapina B | 9.5 | 15.6 | 16.7 | 17.9 | — |
| Krapina C | 11 | 17.4 | 17.9 | 17.5 | 17.1 |
| Ehringsdorf 7 | 10.5–12 | 15.6 | (17.0) | — | (15.0) |
| Modern human sample | 10–12 | 10.3–14.9 | 10.7–15.1 | 11.4–14.1 | 13.7–17.3 |
| Montgaudier | 12.5–14.5 | 12.15 | 13.7 | 13.45 | 13.55 |
| Krapina E | 15–17 | 15.1 | 14.8 | 14.4 | 16.5 |
| Malarnaud 1 | 14–15 | — | — | — | 16.1 |
| Le Moustier 1 ² | 13–16.5 | 15.0 | 14.2 | 15.2 | 16.6 |
| Modern human sample | 12–18+ | 9.9–13.3 | 9.4–13.6 | 10.4–14.5 | 12.1–17.5 |

¹ Comparative measurements from Minugh-Purvis (1988).² The measurements of Le Moustier are taken from a cast (Minugh-Purvis, 1988).TABLE 4. *Corpus height (mm) at canine, P₃, P₄ and M₁*

| Specimen ¹ | Age at death (years) | Canine | P ₃ /dpm ₁ | P ₄ /dpm ₄ | M ₁ |
|----------------------------|----------------------|-----------|----------------------------------|----------------------------------|----------------|
| Krapina B | 9.5 | (29.0) | — | — | 23.5 |
| Krapina C | 11 | (26.0) | — | 22.1 | 21.0 |
| Ehringsdorf 7 | 10.5–12 | 25.6 | — | — | 20.8 |
| Modern human sample | 10–12 | 24.0–28.8 | 18.9–127.8 | 19.8–27.0 | 15.2–25.2 |
| Montgaudier | 12.5–14.5 | 24.9 | 23.3 | 23.3 | 22.45 |
| Krapina E | 15–17 | 23.7 | 25.7 | 26.8 | 25.9 |
| Malarnaud 1 | 14–15 | 18.2 | 20.9 | 20.9 | 19.7 |
| Le Moustier 1 ² | 13–16.5 | 27.5 | 27.3 | 25.4 | 27.2 |
| Petit-Puymoyen 1 | 16–17 | 28.9 | 28.3 | 29.1 | 28.0 |
| Modern human sample | 12–18+ | 23.3–33.1 | 21.4–32.9 | 20.5–31.3 | 20.8–29.9 |

¹ Comparative measurements from Minugh-Purvis (1988).² Measurements of Le Moustier are taken from a cast (Minugh-Purvis, 1988).

ger in age than Montgaudier. Indeed, in these dimensions, it is the smallest specimen in the series of comparable aged individuals. It is interesting that while the thickness of the Montgaudier mandible is consistently within the range of modern humans of 12–18+ years of age, this measure, apart from the measurement at M₁, distinguishes all the other immature Neandertals from living humans (Table 3).

Corpus height (Table 4) of the Montgaudier jaw is small, but not as dramatically reduced in size as corpus width, and it does not differ appreciatively from most of the other juvenile Neandertals, including those both older and younger in age. In these dimensions, the Malarnaud jaw, thought to be a female, is the smallest specimen in the series. The size of the Malarnaud jaw, whose age at death has been estimated to be between 14 and 15 years, is consistently smaller than the range of variation of modern children 12–18+ years of age.

The corpus robusticity index (Table 5) documents a mandibular bone with a relatively narrow breadth combined with a relatively larger height dimension, a pattern of high but narrow corpus shape shared by most of the other immature archaic *Homo sapiens* fossils.

In both corpus height and width, with the exception of the Malarnaud specimen, the Montgaudier jaw is smaller than the jaws of other fossils, even when the comparison is with individuals at a significantly younger age at death.

By producing a mirror image of the occlusal illustration in Figure 1, it is possible to obtain an estimate of the width of the mandibular arch at the middle of the first molar. The internal measurement is 39.5 mm and the external measure is 65.5 mm.

In sum, within the range of normal variation to be expected within an extinct population with some time depth, the morphology of the Montgaudier mandibular fragment does not differentiate it in any meaningful way from

TABLE 5. *Corpus robusticity* (thickness/height \times 100) at P_3/dpm_1

| Specimen ¹ | Age at death (years) | Height (mm) | Thickness (mm) | Index |
|----------------------------|----------------------|-------------|----------------|-----------|
| Teshik Tash 1 | 8.5–11 | 26.5 | 16.6 | 62.6 |
| Modern human sample | 8–12 | 22.2–28.6 | 10.8–14.5 | 43.5–50.7 |
| Modern human sample | 10–12 | 18.9–33.5 | 10.7–15.1 | 43.7–60.3 |
| Montgaudier | 12.5–14.5 | 23.3 | 13.7 | 58.8 |
| Krapina E | 15–17 | 25.7 | 14.8 | 57.6 |
| Malarnaud 1 | 14–15 | 24.0 | 14.0 | 58.3 |
| Le Moustier 1 ² | 13–16.5 | 27.3 | 14.2 | 52.0 |
| Modern human sample | 12–18+ | 21.4–32.9 | 9.6–13.6 | 43.7–60.3 |

¹ Comparative measurements from Minugh-Purvis (1988).

² Measurements of Le Moustier taken from a cast (Minugh-Purvis, 1988).

other immature European Neandertals of comparable age-at-death. It is notable for the small size of its symphysis and the thickness of its ramus, which along with the small size of the preserved teeth, suggest that this fossil, like that from Malarnaud, is from a young female individual. The Montgaudier mandible contrasts in a number of important ways, including the absence of a chin and the presence of multiple mental foramina, from the Qafzeh 11 youth, which is considered an early modern human (Tillier, 1984).

Dentition

The Montgaudier mandibular fragment possesses an intact left I_2 , C and M_1 .

Lateral incisor: The tooth has a small chip on the labial surface (a similar chip marks the labial surface of the canine). Both chips are located at the occlusal surface at the contact facets between them; neither shows any wear and they probably occurred post-mortem, or peri-mortem. The tooth possesses a well-marked, centrally located mesial contact facet in addition to the distal facet with the canine. There is moderate wear on the occlusal surface; the wear is flat with a slight inclination mesiodistally and a thin line of dentine exposure along the edge. An x-ray taken lingually (Fig. 7) shows that the root had reached apical closure. Beginning about two-thirds down the root there is a pronounced distal curvature, with the apex directed in a distal-inferior orientation.

Unusually on a tooth with this amount of occlusal wear, perikymata are easily seen across much of the labial face of the tooth and less easily seen, but nevertheless present, on the lingual face. Figure 8 is a micro-



Fig. 7. X-ray of the Montgaudier mandible. Approximately full size.

graph at $20\times$ of the labial face of the tooth using a Phillips 500 scanning electron microscope at 12 kv. Perikymata have been worn away on the upper quarter of the surface, seen at $40\times$ in Figure 9, but can be clearly observed over the rest of the face all the way to the cemento-enamel junction (CEJ). Figure 10 illustrates the perikymata at $80\times$, about midway down the labial surface. Perikymata are "packed" toward the CEJ as observed on modern human incisors (Dean, 1989; Mann et al., 1990b). Using a scanning electron microscope on an epoxy replica of the labial face, the remaining perikymata were counted five times by the same observer. The five counts averaged 169, with a \pm range of 8. This perikymata number, even without taking into account those lost because of wear on the upper portion of the face, is within the range of modern humans, 75–202 (Bromage and Dean, 1985; Mann et al., 1991a), and within the range of variation in modern Europeans (157–202). It is also

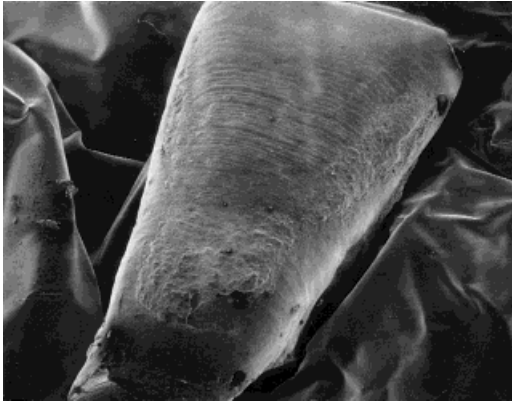


Fig. 8. Scanning electron micrograph at 20 \times of the Montgaudier lateral incisor illustrating the distribution of perikymata on the labial surface.

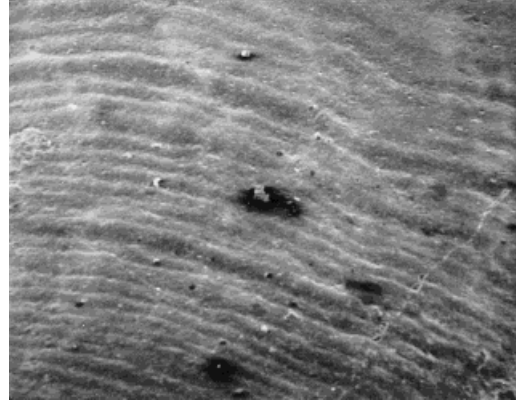


Fig. 10. Scanning electron micrograph at 80 \times illustrating the perikymata present on the middle part of the labial surface.

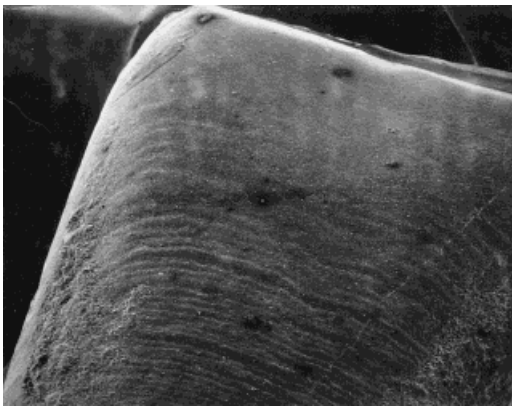


Fig. 9. Scanning electron micrograph at 40 \times of the Montgaudier lateral incisor illustrating the loss of perikymata on the occlusal part of the labial surface.

within the range of incisor perikymata number found on other Neandertals, 119–280 (Dean et al., 1986; Mann et al., 1990b). Because occlusal wear has abraded away some number of perikymata, the total number of these structures present when the crown was first formed was significantly higher. Indeed, the total number may have been outside the upper end of the range of variation established in modern Europeans, and similar to the high perikymata numbers discovered in other Neandertal incisors (Mann et al., 1990b).

The lack of breaks or fractures on the surface of the enamel prevents any examination of the internal structure.

Morphologically, except for the perikymata, the labial face of the tooth lacks any other structures of note. There are no enamel hypoplasias evident on the labial surfaces of either the lateral incisor or the canine.

The lingual surface possesses a small but clearly marked tubercle at the base of the crown. From this tubercle, well defined pillars arise which run along the mesial and distal edge of the lingual face to the occlusal surface. These pillars define a slight depression within which three shallow grooves can be viewed. These originate on the upper surface of the tubercle and run to the occlusal surface. In comparison with the sample of modern human mandibular lateral incisors presented on Plaque P3 of the Dalhberg Dental Plaque series (University of Chicago), the morphology of the lingual (but not the labial) face of the Montgaudier incisor is most similar in size and shape to the central incisor on specimen "a" on this plaque.

Table 6 lists the length and breadth measurements of the Montgaudier I₂ with teeth from other European Neandertals of comparable age, and with Qafzeh 11. Table 7 records the measurements of lateral incisors from various samples of *Homo sapiens*. The Krapina Neandertal sample is listed separately. These teeth tend to be large in comparison with other dental samples from the European Upper Pleistocene, and lumping the Krapina specimens with the general European Neandertal sample dramatically

TABLE 6. *Montgaudier lateral incisor compared with those of Homo sapiens specimens of equivalent age at death*

| Specimen | Side | Bucco-lingual (BL) width (mm) | Mesio-distal (MD) length (mm) |
|----------------------------|------|-------------------------------|-------------------------------|
| Montgaudier | | 6.9 | 5.85 |
| Zaskalnaya ¹ | | 7.05 | 6.45 |
| Sipka ¹ | R | 7.0 | 6.0 |
| | L | 7.0 | 7.0 |
| Ehringsdorf 7 | R | 7.45 | 7.2 |
| | L | 7.5 | 6.8 |
| Teshik Tash 1 ¹ | R | 7.75 | 6.85 |
| | L | 8.0 | 6.8 |
| Le Moustier ¹ | R | 7.9 | 6.8 |
| | L | 7.65 | 6.9 |
| Krapina C | | 8.8 | 7.4 |
| Krapina E | | 8.0 | 7.2 |
| Qafzeh 11 ² | R | 6.4 | 6.0 |
| | L | 6.4 | 6.4 |

Sample characteristics without Qafzeh 11

N = 8

BL mean³: 7.61

BL range: 6.9–8.8

SD³ = .64

MD mean³: 6.76

MD range: 5.85–7.4

SD³ = .49

Sample without Krapina and Qafzeh specimens

N = 6

BL mean³: 7.35

BL range: 6.9–8.0

SD³ = .42

MD mean³: 6.6

MD range: 5.85–7.2

SD³ = .42

¹ Wolpoff (personal communication).

² Tillier (1984).

³ Means and standard deviations (SD) have been corrected for single individuals.

changes the range of variation and gives a somewhat biased view of the total sample.

The mesio-distal length of the Montgaudier I₂ may have been slightly reduced by interstitial wear and the resultant contact facets, but these probably have not significantly altered this dimension.

The size of the Montgaudier lateral incisor is small. Its length and width dimensions make it the smallest incisor among other comparable-in-age Neandertal fossils listed in Table 6. Further, its bucco-lingual width falls below the mean of a sample of Neandertal mandibular lateral incisors measured by Wolpoff (1996, personal communication) and Tillier (1991), and is actually outside of the range of this sample (Table 7). Its length dimension is also small, falling well below the mean for the Neandertal sample. Although the length and breadth dimensions of the Montgaudier incisor fall within the range of the Qafzeh sample, they are below the mean in both measurements.

Canine. The canine is complete. This tooth is fully erupted and possesses both mesial and distal contact facets. Occlusal wear is inclined at a slight angle distally from the mesial edge, resulting in an oval dentin exposure. The x-ray (Fig. 7) shows a relatively broad root canal and a completed root apex. Like the lateral incisor, the root has a marked distally oriented curvature, and like the incisor root, the apex is oriented in a distal-inferior direction.

Perikymata have been preserved on the labial face of the canine. Because there is relatively less wear on the canine, the perikymata count on this tooth more closely approaches the original condition than the reduced number observed on the incisor. The labial face of the canine was examined in a similar fashion as already described for the incisor, with a total number of perikymata of 172 ± 4 recorded, the average of three counts by a single experienced observer. This result is well within the range of perikymata numbers for modern human canines established by Beynon (1992), who obtained a mean number of 159 ± 25.7 . There is, as yet, no published count of perikymata numbers for Neandertal mandibular canines.

Morphologically, the crown is asymmetrical with the distal edge possessing a greater inclination of the occlusal surface, and the mesial edge more vertically oriented. The labial face of the tooth is strongly convex. The lingual face has a poorly marked basal tubercle from which arise two ridges situated along the mesial and distal border of the lingual face. Two other ridges, more centrally placed, are vertically oriented, one of which merges into the basal tubercle.

Metrically (Tables 8 and 9), the B-L width and the M-D length of the tooth are below the mean for a sample of European Neandertals as well as for the comparable-in-age immature Neandertals. However, width and length dimensions are well within the range of variation for canines from these fossil samples.

First molar. The tooth is complete. There is a notable mesial and a well-formed distal contact facet with the mesial facet slightly deforming the mesial surface of the tooth.

TABLE 7. Comparative dimensions (mm) of mandibular lateral incisors from various samples of *Homo sapiens*

| Sample | Bucco-lingual mean | Range | Mesio-distal mean | Range | N |
|--------------------------------|--------------------|-----------|-------------------|-----------|-------|
| Neandertals ¹ | 7.4 | 7.0–8.2 | 6.0 | 5.5–7.3 | 9 |
| Krapina sample ² | 8.06 | 7.0–9.2 | 6.74 | 5.9–7.4 | 10 |
| Qafzeh sample ³ | 7.0 | 6.4–7.8 | 6.52 | 5.7–7.5 | 5 |
| Upper Paleolithic ⁴ | 6.85 | 5.8–8.64 | 6.06 | 4.84–7.26 | 38/25 |
| Mesolithic ⁴ | 6.34 | 5.44–7.18 | 5.91 | 4.88–6.78 | 33/28 |
| Modern Europeans ⁵ | 6.3 | 5.1–7.85 | 5.2 | 3.8–6.5 | 100s |
| Montgaudier | 6.9 | | 5.85 | | |

¹ Wolpoff (1971); Tillier (1991).² Smith (1976).³ Tillier (1984); Vandermeersch (1981).⁴ Flechier (1975).⁵ Wolpoff (1971).TABLE 8. Montgaudier canine compared with those of European archaic *Homo sapiens* of equivalent age at death, and Qafzeh 11 and Jebel Irhoud 3

| Specimen | Side | Bucco-lingual (BL) width (mm) | Mesio-distal (MD) length (mm) |
|-----------------------------|------|-------------------------------|-------------------------------|
| Montgaudier | | 6.8 | 7.5 |
| Zaskalnaya ¹ | R | — | 7.4 |
| | L | 7.85 | 7.15 |
| Sipka ¹ | | — | 7.4 |
| Ehringsdorf child | | 8.0 | 8.2 |
| Krapina E | | 9.5 | 8.8 |
| Petit Puymoyen | | — | 8.5 |
| Le Moustier ¹ | R | 9.5 | 7.9 |
| Qafzeh 11 ² | R | 8.7 | 8.2 |
| | L | 8.8 | 8.0 |
| Jebel Irhoud 3 ³ | L | 9.4 | 8.8 |

Sample characteristics without Qafzeh 11 or Irhoud 3

| | |
|-----------------------------|-----------------------------|
| N = 5 | N = 7 |
| BL mean ⁴ : 8.65 | MD mean ⁴ : 7.93 |
| BL range: 8.0–9.5 | MD range: 7.4–8.8 |
| SD ⁴ = .80 | SD ⁴ = .58 |

Sample without Krapina, Qafzeh and Irhoud specimens

| | |
|-----------------------------|----------------------------|
| N = 4 | N = 6 |
| BL mean ⁴ : 8.43 | MD mean ⁴ : 7.8 |
| BL range: 7.85–9.5 | MD range: 7.15–8.5 |
| SD ⁴ = .75 | SD ⁴ = .49 |

¹ Wolpoff (personal communication).² Tillier (1984).³ Hublin and Tillier (1981).⁴ Means and standard deviations (SD) have been corrected for single individuals.

The facets have contributed to a reduction of the mesio-distal length.

A lateral x-ray (Fig. 7) documents apical closure of all of the roots. The x-ray also shows that the pulp chamber extends apically, thus placing the bifurcation between mesial and distal roots in a more apical position. This enlargement of the pulp chamber was termed by Keith (1913) *taurodontism*, and has often been considered to be commonly associated with Neandertal

molars (e.g. Stringer and Gamble, 1993; Wolpoff, 1996). However, as Blumberg et al. (1971) and Ackerman et al. (1973), among many others, have noted, molars with apically expanded pulp chambers are not uncommon in living human populations. Indeed, if the pulp chamber of the Montgaudier M₁ is compared to the variations described by Shaw (1928) and most recently pictured by Ackerman et al. (1973), the Montgaudier specimen is most appropriately described as *mesotaurodont*, with less expansion than those termed *hypertaurodont*.

On the occlusal surface, there are five cusps organized in the basic Dryopithecus Y-5 pattern (Gregory and Hellman, 1926). That is, the hypoconid (Hy^d) is in contact with the distobuccal base of the metaconid (Me^d). This arrangement is variably found in Neandertal first molars (i.e. Patte, 1960). The trigonid is markedly smaller than the talonid, and there is a notable talonid basin, traits that are also variable on other Neandertal lower molars (Patte, 1960). A slight wrinkle separates the Me^d from the entocoronid (En^d), giving the appearance of an accessory cusp between these two major cusps. The hypoconulid (HI^d) is positioned in a bucco-distal, rather than in a distal position. There is no trace of a protostylid. There is a small anterior fovea, but only traces of the posterior fovea remain, much of the original structure having been lost because of occlusal wear.

As is typical of anterior mandibular molars, crown wear is heavier on the buccal half of the tooth, with the protoconid (Pr^d) possessing the greatest abrasion and slight

TABLE 9. Comparative dimensions (mm) of mandibular canines of samples of *Homo sapiens*

| Sample | Bucco-lingual mean | Range | Mesio-distal mean | Range | N |
|--------------------------------|--------------------|----------|-------------------|---------|-------|
| Neandertals ¹ | 8.7 | 8.2–10.0 | 7.7 | 7.0–8.5 | 14 |
| Krapina sample ² | 9.3 | 8.0–10.2 | 8.1 | 7.0–8.8 | 12 |
| Qafzeh sample ³ | 8.95 | 7.8–9.9 | 8.15 | 7.5–8.8 | 6 |
| Upper Paleolithic ⁴ | 8.43 | 7.7–9.8 | 6.93 | 6.0–7.8 | 29/34 |
| Mesolithic ⁴ | 7.96 | 7.0–8.9 | 6.9 | 6.7–7.7 | 31/28 |
| Modern Europeans ⁵ | 8.1 | 7.0–9.9 | 6.9 | 5.0–8.5 | 100s |
| Montgaudier | 8.4 | | 7.5 | | |

¹ Wolpoff (1971); Tillier (1991).² Smith (1976).³ Tillier (1984); Vandermeersch (1981).⁴ Flechier (1975).⁵ Wolpoff (1971).

dentin exposure. Immediately behind the Pr^d, the Hy^d shows somewhat less wear and the Hl^d still less. The lingual cusps, the Me^d and En^d possess only slight wear.

Tables 10 and 11 compare length and breadth dimensions of the Montgaudier molar with those from immature Neandertals of comparable age at death, a series of Neandertals and samples of Upper Paleolithic, Mesolithic and living humans. Both the B-L breadth and the M-D length dimensions of the molar tooth are significantly below the mean, but within the range of comparable age Neandertal individuals as well as a broader sample of European Neandertals. Although the Montgaudier molar is a little longer than the Qafzeh 11 tooth, in comparison with the average of length and breadth dimensions of the entire sample from Qafzeh, it is notably smaller. It should be kept in mind that the M-D diameter has been somewhat reduced because of interstitial wear. This, however, probably did not significantly reduce the M-D length of this tooth and its small size is an accurate reflection of its true dimension.

In sum, the three preserved teeth of the Montgaudier mandible do not exhibit a suite of unique features. The incisor possesses a large number of perikymata though a significant, though unknown, number have been abraded away. The molar possesses a degree of pulp chamber enlargement that is a feature of many Neandertal molars. The single most distinctive set of features of the preserved teeth is their small size, and this may reasonably be utilized, along with the small dimensions of the mandibular bone, to identify this specimen as a female.

TABLE 10. Montgaudier first molar compared with European archaic *Homo sapiens* specimens of equivalent age at death, and Qafzeh 11 and Jebel Irhoud 3

| Specimen | Side | Bucco-lingual width (mm) | Mesio-distal length (mm) |
|-----------------------------|------|--------------------------|--------------------------|
| Montgaudier | | 10.15 | 11.2 ¹ |
| Zaskalnaya 6 ² | R | 10.3 | 11.4 |
| | L | 10.4 | 11.0 |
| Ehringsdorf child | | 10.5 | 11.65 |
| Teshik Tash 1 ² | R | 11.1 | 11.8 |
| | L | 11.15 | 11.55 |
| Krapina C | | 11.8 | 12.3 |
| Krapina E | | 12.0 | 13.2 |
| Malarnaud 1 | | 11.1 | 12.4 |
| Petit Puymoyen ² | | — | 11.1 |
| Le Moustier ² | R | 11.4 | 12.4 |
| | L | 11.35 | 12.0 |
| Qafzeh 11 ³ | R | 10.7 | 10.7 |
| | L | 10.8 | 10.7 |
| Jebel Irhoud 3 ⁴ | R | 12.3 | 14.4 |
| | L | 12.2 | 14.5 |

Sample characteristics without Qafzeh 11 or Irhoud 3

| | |
|------------------------------|------------------------------|
| N = 8 | N = 9 |
| BL mean ⁵ : 11.04 | MD mean ⁵ : 11.88 |
| BL range: 10.15–12.0 | MD range: 11.0–13.2 |
| SD ⁵ = .69 | SD ⁵ = .70 |

Sample without Krapina, Qafzeh and Irhoud specimens

| | |
|------------------------------|------------------------------|
| N = 6 | N = 7 |
| BL mean ⁵ : 10.87 | MD mean ⁵ : 11.62 |
| BL range: 10.15–11.8 | MD range: 11.1–12.4 |
| SD ⁵ = .67 | SD ⁵ = .48 |

¹ Abbreviated by mesial and distal contact facets.² Wolpoff (personal communication).³ Tillier (1984).⁴ Hublin and Tillier (1981).⁵ Means and standard deviations (SD) have been corrected for single individuals.

AGE AT DEATH

Based on comparisons of a number of techniques, Saunders et al. (1993) concluded that the estimation of the age at death of immature modern humans is most accurately determined from analysis of develop-

TABLE 11. Comparative dimensions (mm) of mandibular first molars from various samples of *Homo sapiens*

| Sample | Bucco-lingual mean | Range | Mesio-distal mean | Range | N |
|--------------------------------|--------------------|------------|-------------------|------------|-------|
| Neandertals ¹ | 10.9 | 9.6–11.5 | 11.5 | 10.3–12.5 | 8 |
| Krapina sample ² | 11.4 | 10.0–12.6 | 12.48 | 11.2–13.9 | 12 |
| Qafzeh sample ³ | 11.63 | 10.7–12.8 | 11.79 | 10.7–13.2 | 9 |
| Upper Paleolithic ⁴ | 10.98 | 9.8–12.0 | 11.19 | 9.26–12.46 | 44/45 |
| Mesolithic ⁴ | 11.08 | 10.04–11.9 | 11.27 | 9.72–12.74 | 40/38 |
| Modern Europeans ⁵ | 10.7 | 9.2–12.7 | 11.2 | 9.8–13.0 | 100s |
| Montgaudier | 10.15 | | 11.2 ⁶ | | |

¹ Wolpoff (1971); Vandermeersch (1991).² Smith (1976).³ Tillier (1984); Vandermeersch (1981).⁴ Flechier (1975).⁵ Wolpoff (1971).⁶ Abbreviated by mesial and distal contact facets.

mental events in the dentition. Several scholars (reviewed in Mann et al., 1990a) have questioned the validity of using modern human standards of dental eruption to assess the age at death of fossil hominines. While there continues to be active debate about the appropriateness of establishing the age at death of specific australopithecine fossils on the basis of modern human standards (i.e. Dean, 1989; Smith, 1992; Macho and Wood, 1995), there is evidence from the study of the Nariokotome *Homo erectus* youth (Walker and Leakey, 1993) that early members of the genus *Homo* were maturing in a manner not very different from that of modern humans (e.g. Begun and Walker, 1993; Smith, 1993).

Legoux (1966, 1970) examined the stages of dental development in a number of immature Neandertals, including the specimens from La Quina, Pech de l'Aze and the immature mandible Ehringsdorf 7. His results, when interpreted from the perspective of the known ranges of variation in dental development and eruption present in modern populations, do not distinguish these fossil specimens from modern humans. In a study of the Gibraltar Neandertal child, Dean et al. (1986) suggested that this individual was following an essentially modern human pattern of growth and development. Tillier (1989, 1995) has shown that it is not possible to distinguish patterns of Neandertal cranial, dental and skeletal growth from that of equivalent-in-age living humans, as well as early modern humans of the European Upper Paleolithic.

In his assessment of dental development and wear in the Krapina Neandertals, Wolpoff (1979) concluded that the third molars may have erupted earlier than is generally the case in modern humans, perhaps at 15 years. This conclusion has also been supported by Simpson et al. (1990). Fanning and Moorrees (1969) have documented third molar eruption as falling between 13 and 16 years in a sample of living native Australians.

On the basis of their examination of dental microstructure, Dean et al. (1986) concluded that the rate of Neandertal maturation may have been at the high end of the modern human range. In a recent study, Tompkins (1996) compared the relative dental development of three large samples of living humans to a sample of Neandertals, archaic *Homo sapiens* and Upper Paleolithic humans. Tompkins (1996) concluded that although there were several small differences in the timing of various dental developmental events, dental maturation in these earlier humans was within the range of the living human samples. However, in a study that contrasts with these results, Ramirez-Rozzi (1993, 1996) concluded from his examination of the enamel microstructure of the mature Neandertal with heavily worn teeth from Zafarraya in Spain that these hominines were developing their dental enamel at a faster rate than that characteristic of modern humans. Therefore, the Neandertals may have undergone a more rapid rate of dental maturation. These assertions have yet to be supported.

Thus, apart from the still to be confirmed work of Ramirez-Rozzi, and the questions raised about the timing of third molar eruption, which is not directly applicable to the Montgaudier specimen because of its young age, there is no compelling evidence to reject the use of modern human dental development standards to estimate the age at death of this individual.

In their original published announcement of the discovery, Duport and Vandermeersch (1976) estimated the age at death of the Montgaudier individual as between 12 and 13 years. This estimate was based on the presence of a distal contact facet on the first molar, indicating that "la M2 était complètement sortie et en fonction depuis quelque temps" (Duport and Vandermeersch, 1976:1161).

An x-ray (Fig. 7) reveals the completed canine root, as well as the completed roots of the P₃ and P₄. Finally, the mesial surface of the mesial root hole of the left M₂ has been preserved, and its completed margins can be seen at the bottom of the alveolus. In addition to these developmental events, the incisor and canine have sufficient occlusal wear for dentin exposure to have occurred, with the first molar showing dentin exposure on the mesial-buccal cusp (Pr^d).

These developmental events can be compared with those documented in modern human populations. Garn et al. (1959) examined dental maturation in a sample of 255 North American children of European descent. Nolla's (1960) study was composed of a total 50 children, 25 of each sex. In a larger study, Moorress et al. (1963) looked at the developing post-incisor dentitions of 246 North American children of European descent. Fass (1969) compiled data on the dental development of 786 American children and Hurme (1949) gathered data on the dental eruption times of 96,000 northern European children. The results of these studies, as applied to the state of maturation of the preserved teeth in the Montgaudier mandible, are summarized in Table 12.

Considering the stage of dental development that the Montgaudier mandible possesses, and the known range of variation observed in modern humans (Table 12), the

TABLE 12. *Developmental events in the dentitions of living children employed in estimating the age at death of the Montgaudier mandibular fossil*

| |
|--|
| Completion of canine root |
| Earliest x-ray evidence: 8.2 years; median: 12–13 years ¹ |
| Apical closure, girls, mean: 12 years ² |
| Apical closure, mean: 11–13 years; range: 9.25–13.9 years, ± 2 SD ³ |
| Completion of first premolar root |
| Earliest x-ray evidence: 9.75 years; median: 12.2 years ¹ |
| Apical closure, American girls, range: 11.1–14.1 years ⁴ |
| Apical closure, girls, mean: 12.5 years ² |
| Apical closure, mean: 12.25 years; range: 9.9–15.0 years, ± 2 SD ³ |
| Completion of second premolar root |
| Earliest x-ray evidence: 10.5 years; median: 13 years ¹ |
| Apical closure, American girls, range: 12.1–14.6 years ⁴ |
| Apical closure, girls, mean: 14.5 years ² |
| Apical closure, mean: 13.6 years; range: 11.1–16.75 years, ± 2 SD ³ |
| Eruption of second molar |
| European girls: 10.9–13.6 years ⁵ |
| Completion of second molar root |
| Apical closure, American girls, range: 13.1–17.1 years ⁴ |
| Apical closure, girls, mean: 15.5 years ² |
| Apical closure, mesial root, mean: 13.5 years; range: 11.1–17.0 years, ± 2 SD ³ |

¹ Fass (1969).

² Nolla (1960).

³ Moorress et al. (1963).

⁴ Garn, et al. (1959).

⁵ Hurme (1949).

most appropriate age estimate for this specimen is between 12.5 and 14.5 years.

It is possible that the age at death was somewhat older, perhaps as old as 17 years, the upper end of the range of variation documented by Moorress and his colleagues for completion of second molar roots. However, this seems unlikely. The relative amount of occlusal wear on the preserved teeth is insufficient, given the usual pattern of heavy wear on Neandertal anterior teeth, to support an age at death greater than 15 years.

SEX IDENTIFICATION

The identification of the sex of a fossil specimen, even one that is relatively complete, is often very difficult. In some fossil samples, dimorphism apparently was considerable, at least in some aspects of their morphology. For example, Wolpoff (1975, 1976) used maxillary canine size to identify

male and female australopithecines. Heim (1974) identified postcranial size differences in Neandertals and suggested that these could be used to distinguish members of each sex. Later, however, he also reported that there was little apparent sexual dimorphism in the skulls of Neandertals (Heim, 1981–1982). Wolpoff (1980) examined the possible sexual dimorphism in samples of archaic *Homo sapiens* crania from Europe, and de Lumley et al. (1982) have remarked on the size differences between Arago mandibles 13 and 21 and their possible gender identity. However, Mann (1981) found little evidence of sexual dimorphism in the preserved skeletal materials of the Zhoukoudian *Homo erectus* sample and there is clearly a wide range of variation in the expression of dimorphic features in modern humans (Frayer and Wolpoff, 1985). Given the poor quality of the preserved fossils, their incompleteness, and the extremely small samples sizes which must be employed as representative of populations scattered over wide geographic areas and temporal horizons, there is no assurance that any of these assertions are correct.

Both Wolpoff (1976, 1979) and Oxnard (1987) have considered the question of sexual dimorphism in the Neandertal dentition. Wolpoff (1979) concluded after an examination of the Krapina sample that the dentition was not a reliable predictor of sex in Neandertals. He noted that both very large and small teeth could be found in the same dentition, and that no single tooth could be reasonably employed to identify the sex of a particular specimen. However, the Krapina dental sample is composed of teeth whose sizes are at the upper end of the Neandertal range, and in many cases establish the largest size of a particular tooth. Thus, this sample may not be the most appropriate model for considering the question of the significance of tooth size in judging sex differences in Neandertals.

Oxnard (1987) metrically evaluated a number of dental samples of extinct hominines in his examination of the pattern of sexual dimorphism in human evolution, including the teeth of a sample of Neandertals. Oxnard discovered significant sexual dimorphism in size in a number of teeth in

this sample, noting, for example, that the breadth of the canines “demonstrates unequivocal and statistically significant bimodal distributions” (1987:71). According to Oxnard, the range of lower canine breadth in this sample is 7.5–10.5 mm with males ranging from 9.5 to 10.5 mm and females from 7.5 to 9.0 mm. The breadth of the Montgaudier canine is 8.4, within the female range. Oxnard also presents a summary table that identifies the mandibular incisors, first premolar and the maxillary lateral incisor, both premolars and the third molar as teeth with significant dimorphism in this sample. Unfortunately, Oxnard provides no specific comparisons or numerical data to support these observations and they must therefore remain provisional.

The teeth in the Montgaudier mandible are small in size (Tables 6–11), with measurements that fall at the very low end, or in the case of incisor breadth, actually outside, the Neandertal range. Unlike the situation described by Wolpoff for the Krapina sample, where teeth in the same jaw would vary in size from large to small, all three teeth in the Montgaudier mandible are small. If the dimensions of the teeth are combined with the small size of the mandibular bone, at the symphysis and in the dimensions of the corpus, it is reasonable to conclude that the Montgaudier specimen is that of a female.

CONCLUSIONS

The partial mandible from Montgaudier Cave in the Charente (France) may derive from the end of Middle Pleistocene or the very beginning of the Upper Pleistocene, a time which would place it earlier than the bulk of the Neandertal specimens thus far discovered in western Europe. It is an immature specimen whose pattern of dental eruption suggests an age at death of between 12.5 and 14.5 years and whose size argues for female gender.

The overall morphology of the mandibular fossil from the Montgaudier does not distinguish it from other archaic *Homo sapiens* youngsters of the Upper Pleistocene. Morphologically, the chin region is similar to that of contemporary Neandertal preadults from Europe, like Malarnaud. The mental trigon is small and is not accompanied by

lateral tubercles. This condition is unlike that observed in the Qafzeh 11 child, of approximately the same dental age at death, whose symphyseal region preserves a well-developed chin region similar to that in modern humans. On the posterior symphyseal region, the Montgaudier mandible is gracile, and lacks the alveolar shelf sometimes encountered on other immature Neandertal jaws. Multiple mental foramina, a feature often associated with Neandertal mandibles, are present on the preserved portion of the corpus.

The generally small size of the symphysis and the width of the other parts of the corpus suggest that the mandible was from a female individual, a conclusion supported by an examination of the preserved teeth, a left I_2 , C and M_1 , whose length and width dimensions are well below the mean for Upper Pleistocene Europeans, and are sometimes even outside the range of variation of these samples.

Morphologically, the dentition demonstrates similar variations seen in the mandibular bone. An x-ray shows that the molar possessed a degree of taurodontism. A count of preserved perikymata results in a total within the range of other European Neandertal incisors, as well as for the incisor teeth of living Europeans.

The Montgaudier specimen provides an important addition to our emerging understanding of the range of variation that characterized the later Pleistocene inhabitants of Europe, and broadens our data base for the exploration of the patterns of growth and development experienced by these earlier inhabitants of Europe.

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